Agropedology 2005, 15 (1) 76-79

Soil–site suitability evaluation of hot arid westerm plain soils of Rajasthan

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Abstract : The information generated during soil-site suitability evaluation of hot arid western plain soils of Rajasthan has been utilized for land use planning as it helps in expansion of area under particular crop. Four soil profiles and 32 minipits, 8 surrounding each profile site, were studied for making the soil/profile site representative. The soils are deep, well drained, low in organic matter and CEC. Suitability for mustard, wheat, gram clusterbean was evaluated by matching the climat and soil-site characteristics of each unit with the crop requirement. Maximum economic yield of pearlmillet, mustard, wheat, gram and guar can be obtained from Hanumangarh followed by Ganganagar soils while the minimum is obtained from Bikaner soils.

Additional Key words : Suitability, land use planning, economic yield, non-suitable

Introduction

The agro-climatic and soil characteristics of any region or place largely determines the degree of success of any cropping enterprise. Though this fact is recognized very widely, studies to generate quantified information on the combined influence of agro-climatic and soil-characteristics on crop performance are scattered. Quantitative information on land evaluation helps in better land use planning as yield levels have to be higher to sustain the increasing non-farming population (Tang and Ranst 1998).

Land suitability evaluation is the process of determining the potential of the land for alternative uses and forms a pre-requisite for land use planning (Sehgal 1995). It integrates soil characteristics with climate and landuse. Optimal requirement of a crop is always region specific, and soil site characteristics determine the degree of suitability for land use and help in planning expansion of area under a particular crop. Pearlmillet, mustard, wheat, gram and clusterbean are the main crops grown in hot arid western plain of Rajasthan. Hence an attempt has been made in the present investigation to study the suitability of soils for these crops.

Materials and Methods

The area lies between 26^0 06' to 29^0 34' N latitude and 73^0 01' to 74^0 21' E longitude. Four soil profiles and thirty two minipits, 8 surrounding each profile site, from Mandore (Jodhpur), Ganganagar, Hanumangarh and Bikaner were studied. Sandstone, limestone, gypsum, quartz and granite are chief rock/ minerals of common occurrence. The hot arid part of western Rajasthan receives less than 500 mm of rainfall. The mean annual temperature ranges between 24^{0}C and 27^{0}C, the maximum temperature is in the month of May and June (46^{0}C). The mean winter temperature drops to 12.9^0 C with minimum range of 5 – 2.3^0 C in the month of January.

The profiles were dug upto 150 cm and studied for their morphology (Soil Survey Division Staff 1995). The soil samples were analyzed for physical and chemical characteristics and the soils were classified as per keys to soil taxonomy (Soil Survey Staff 1998). Based on the soil – site characteristics and the requirement of crops, the soil site suitability was worked out as per Sys *et al.* (1993). Suitability ratings were calculated using the expression as given below.

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$$\text{Economic yield factor (value)} = \frac{\text{Most limiting factor}}{\text{(average of other limiting factors)}} \Big/ 100$$

The value arrived is converted into suitable class as suitable (S1) - 60-80, moderately suitable (S2) - 40-60, marginally suitable (S3) - 20-40 and not suitable (N) - <20.

Result and Discussion

Soil Charateracteristics

The soils are very deep (>150cm) and are yellowish in hue and darker in chroma (Table 1). Yellowish colour pattern is attributed to dominant sand fraction and low organic matter content of these soils. The structure of the surface horizon of the soil is single grain to granular with weak to moderate strength indicating better association with aeolian character (Kolarkar *et al.* 1989; Sehgal 1995). The sub-surface horizons show subangular blocky structure of weak to moderate strength.

The CEC varied from 2.7 to 14.9 cmol (p^+) kg^{-1} (Table 3). The low CEC values may be due to the dominance of low activity clay having lower surface charge indicative of low retentivity of native/added nutrients in soils. The organic carbon content ranged from 0.08 to 0.42 per cent. The pH values ranged from 8.2 to 8.4 and EC from 0.2 to 0.4 dSm^{-1}. The lower value is attributed to relatively low weathering and light texture.

Table 1. Morphological characteristics of the soils

Horizon	Depth (cm)	Boundry	Matrix Colour D	Matrix Colour M	Texture	Structure	Consistency	Porosicty	Roots	Nodules	Effervescence
				P1 - Mandore : Mixed (calcareous) hyperthermic Typic Torripsamments							
AP	0-16	c s	10YR 5/6	10 YR 4/4	ls	f1gr	shfrss	vfm	vfc	vff	ev
2C1	16-35	g s	10YR 5/6	10YR 4/4	ls	m1sbk	shfrss	vfm	vfc	vff	ev
3C2	35-62	g s	10YR 5/6	10YR 4/4	ls	m1sbk	shfrss	vfm	vfc	vff	ev
4C3	52-90	g s	10YR 5/6	10YR 4/4	sl	m sbk	shfrss	vfm	vfc	vff	ev
5C4	90-120	i w	10YR 5/6	10YR 4/4	ls	m1sbk	shfrss	vfm	vfc	vff	ev
6C5	120-150+		10YR 5/6	10YR 4/4	sl	m1 sbk	shfrss	vfm	vfc	vff	ev
				P2 - Ganganagar : Fine-loamy, mixed (calcareous) Typic Haplustepts							
AP	0-9	c s	10YR 6/4	10Y R5/4	sl	m2gr	shfrss	vfm	vfm		es
Bw1	9-27	g s	10YR 6/4	10Y R5/4	scl	m2sbk	shfrss	vfm	vfm		es
Bw2	27-54	g s	10YR 6/4	10Y R5/4	sl	m2sbk	shfrss	vfm	vfm		es
Bw3	54-89	g s	10YR 6/4	10Y R5/4	sl	m2sbk	shfrss	vfm	vfm		es
Bw4	89-120	g s	10YR 6/4	10Y R5/4	sl	m2sbk	shfrss	vfm	vfm		es
Bw5	120-150		10YR 6/4	10Y R5/4	sl	m2sbk	shfrss	vfm	vfm		es
				P3 - Hanumangarh : Fine-loamy, mixed (calcareous) Typic Haplustepts							
AP	0-10	c s	10YR 6/3	10YR 5/4	sl	m2gr	shfrss	vfm	vfm		es
Bw1	10-35	g s	10YR 6/3	10YR 5/4	scl	m2sbk	shfrss	vfm	vfm		es
Bw2	35-65	g s	10YR 6/3	10YR 5/4	scl	m2sbk	shfrss	vfm	vfm		es
Bw3	65-95	g s	10YR 6/3	10YR 5/4	scl	m2sbk	shfrss	vfm	vfm		es
Bw1ca	95-124	g s	10YR 6/3	10Y R 5/4	sl	m2sbk	shfrss	vfm	vfm		es
Bw2ca	124-150+		10YR 6/3	10Y R 5/4	sl	m2sbk	shfrss	vfm	vfm		es
				P4 - Bikaner : Mixed (calcareous) Typic Torripsamments							
AP	0-12	c s	10YR 6/4	10YR 5/4	s	fisg	lfrso	vfm	fm		e
2C1	12-28	g s	10YR 6/4	10YR 5/4	ls	fisg	lfrso	vfm	fm		e
2C2	28-49	g s	10YR 6/4	10YR 5/4	ls	fisg	lfrso	vfm	fm		e
2C3	49-72	g s	10YR 6/4	10YR 5/4	ls	fisg	lfrso	vfm	fm		e
2C4	72-105	g s	10YR 6/4	10YR 5/4	ls	fisg	lfrso	vfm	fm		e
2C5	105-128	g s	10YR 6/4	10YR 5/4	ls	fisg	lfrso	vfm	fm		e
2C6	128-150+		10YR 6/4	10YR 5/4	ls	fisg	lfrso	vfm	fm		e

Table 2. Some chemical properties of soils

Horizon	Depth (cm)	pH (1:2)	EC	Organic carbon	$CaCO_3$	Exchangeable cations Ca+Mg	Na	K	CEC	BS
			(dS m^{-1})	←——— (%) ———→		←——— [cmol (P^+) kg^{-1}] ———→				(%)
				P1 - Mandore : Mixed (calcareous) hyperthermic Typic Torripsamments						
Ap	0-16	8.1	0.4	0.15	3.5	5.0	0.6	0.5	6.6	97.0
2C1	16.35	8.2	0.3	0.15	5.3	5.2	0.5	0.6	5.8	95.0
3C2	35-62	8.3	0.3	0.15	5.5	4.1	0.5	0.5	4.8	86.0
4C3	62-90	8.4	0.4	0.12	8.5	3.4	0.5	1.0	5.6	93.0
5C3	90-120	8.4	0.4	0.09	11.0	3.9	0.5	0.8	4.3	98.0
6C5	120-150+	8.5	0.5	0.08	12.0	3.9	0.4	0.7	4.4	85.0
				P2 - Ganganagar : Fine-loamy, mixed (calcareous) Typic Haplustepts						
Ap	0-9	8.2	0.3	0.40	2.5	2.9	0.2	0.2	11.9	94.0
Bw1	9-27	8.2	0.3	0.42	5.3	3.2	0.2	0.1	14.9	89.0
Bw2	27-54	8.2	0.3	0.42	5.8	3.8	0.2	0.1	11.9	96.0
Bw3	54-89	8.2	0.3	0.30	6.0	3.8	0.2	0.2	10.0	93.0
Bw4	89-120	8.2	0.3	0.32	9.8	3.1	0.1	0.2	10.4	91.0
Bw5	120-150+	8.2	0.3	0.23	8.0	2.5	0.1	0.1	13.3	84.0
				P3 - Hanumangarh : Fine-loamy, mixed (calcareous) Typic Haplustepts						
Ap	0-10	8.3	0.4	0.40	2.0	3.1	0.2	0.2	14.6	95.0
Bw1	10-35	8.3	0.3	0.42	3.0	3.4	0.1	0.1	13.2	90.0
Bw2	35-65	8.4	0.3	0.37	5.3	4.1	0.2	0.2	11.2	90.0
Bw3	65-95	8.3	0.4	0.35	5.5	3.8	0.1	0.1	12.4	93.0
Bw4	95-124	8.4	0.4	0.25	7.8	3.2	0.1	0.1	13.7	92.0
Bw5	124-150+	8.4	0.5	0.28	10.0	2.7	0.1	0.1	14.6	85.0
				P4 - Bikaner : Mixed (calcareous) Typic Torripsamments						
Ap	0-12	8.3	0.3	0.23	2.2	3.2	0.5	0.3	2.9	92.0
2C1	12-28	8.3	0.3	0.20	3.1	3.8	0.4	0.3	2.90	95.0
2C2	28-49	8.4	0.2	0.20	3.5	3.8	0.4	0.3	2.90	96.0
2C3	49-72	8.4	0.2	0.18	3.9	4.2	0.3	0.3	2.77	92.0
2C4	72-105	8.4	0.2	0.13	6.4	4.0	0.5	0.3	3.34	89.0
2C5	105-128	8.4	0.2	0.13	9.8	3.8	0.4	0.3	2.90	92.0
2C6	128-150+	8.4	0.2	0.12	9.7	3.8	0.4	0.3	2.90	95.0

The calcium carbonate content ranged from 5.51 to 7.68 per cent. An increasing trend down the depth has been observed. The exchangeable Ca + Mg varied from 2.5 to 5.0 cmol (p^+) kg^{-1}. The exchangeable Na varied from 0.1-0.6 cmol (p^+) kg^{-1} and K from 0.1-1.0 cmol (p^+) kg^{-1}. Lack of specific trend of exchangeable Na in surface horizons might be due to high temperature prevailing in the area.

Soil-site suitability evaluation

For pearlmillet, maximum of 79.1 per cent of average economic yield can be obtained from Hanumangarh soils and a minimum of (52.8 per cent) from Bikaner soils. For mustard crop, a maximum of 80.7 per cent of average economic yield can be obtained from Hanumangarh soils and a minimum of 53 per cent from Bikaner soils. For wheat crop, a maximum of 62.2 per cent can be obtained from Hanumangarh soils and a minimum of 16.4 per cent from Bikaner soils. A maximum of 62.7 and a minimum 49.6 per cent of average economic yield can be obtained from Hanumangarh and Bikaner soils respectively for gram. For clusterbean, a maximum of 77.9 per cent of average

Table 3. Soil-Site Suitability evaluation (Sys et al., 1993) for relevant land utilization types.

Pedons/ Crops	Rainfal	lTopography	Drainage	Texture	Depth	$CaCO_3$	CEC	BS	Soil-Site suitability rating/(class)
pearlmillet									
1	90	95	95	68	95	95	75	95	62.2 (S_3)
2	85	90	95	92	98	95	85	95	78.9 (S^3)
3	84	95	95	94	96	96	88	95	79.1 (S^2)
4	85	90	95	65	90	96	60	95	52.8 (S^2_3)
Mustard									
1	92	95	95	68	95	95	75	95	62.3 (S_3)
2	87	90	95	90	98	95	85	95	78.9 (S^2)
3	86	95	95	92	96	96	88	95	80.7 (S^2)
4	87	90	95	65	90	96	60	95	53.0 (S^2_3)
Wheat									
1	75	85	95	20	95	95	75	95	17.6 (N_2)
2	68	80	95	70	98	95	85	95	60.1 (S^2_3)
3	68	85	95	85	96	96	88	95	62.2 (S^3)
4	68	80	95	20	90	96	60	95	16.1 (N^3_2)
Gram									
1	75	85	95	60	95	95	75	95	52.7 (S_3)
2	68	75	95	85	98	95	85	95	53.8 (S^3)
3	68	80	95	95	96	96	88	95	62.7 (S^3)
4	68	73	95	60	90	96	62	95	49.6 (S^2_3)
Guar									
1	90	95	95	80	95	90	75	95	68.6 (S_3)
2	85	90	95	83	98	88	85	95	75.4 (S^2)
3	84	95	95	85	96	95	88	95	72.9 (S^2)
4	85	90	95	80	90	96	60	95	54.1 (S^2_3)

economic yield can be obtained from Hanumangarh soils and a minimum of 44.1 per cent from Bikaner soils (Table 3). Thus by the quantitative method of soil-site suitability evaluation in hot and western plain, it was found that the maximum yield can be obtained from Hanumangarh soils and minimum from Bikaner Soils for all the crops. The Mandore soils are marginally suitable (S_3) for pearlmillet and gram, moderately suitable for mustard and clusterbean and non suitable (N_2) for wheat. The Ganganagar soils are moderately suitable (S_2) for pearlmillet, mustard, clusterbean and are marginally suitable (S_3) for wheat and gram. The Hanumangarh soils are moderately suitable (S_2) for the pearlmillet, mustard, wheat, gram and clusterbean, and marginally suitable (S_3) for wheat.

Acknowledgements

The first author is grateful to the Indian Council of Agricultural Research for the award of Senior Research Fellowship during the study.

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Received April 2004 : Accepted May 2005